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International Space Station

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International Space Station
U.S. Space Station History

Introduction

Space stations have long been seen as a laboratories for learning about the effects of space conditions and as a springboard to the Moon and Mars. In the United States, the Apollo lunar program preempted early station efforts in the early 1960s, and changing priorities in the U.S. deferred post-Apollo station efforts to the 1980s. Since 1984, space station design has evolved in response to budgetary, programmatic, and political pressures, becoming increasingly international in the process. This evolution has culminated in International Space Station, orbital assembly of which will begin in 1997.

The Beginning (1869-1957)

The concept of a staffed outpost in Earth orbit dates from just after the Civil War. In 1869, American writer Edward Everett Hale published a science fiction tale called “The Brick Moon” in the *Atlantic Monthly*. Hale’s manned satellite was a navigational aid for ships at sea. Hale proved prophetic. The fictional designers of the Brick Moon encountered many of the same problems with redesigns and funding that NASA would with its station a century later.

In 1923, Hermann Oberth, a Romanian, coined the term “space station.” Oberth’s station was the starting point for flights to the Moon and Mars. Herman Noordung, an Austrian, published the first space station blueprint in 1928. Like today’s International Space Station, it had modules with different functions. Both men wrote that space station parts would be launched into space by rockets.

In 1927, American Robert Goddard made a major breakthrough by launching the first liquid-fueled rocket, setting the stage for the large, powerful rockets needed to launch space station parts into orbit. Rocketry advanced rapidly during World War II, especially in Germany, where the ideas of Oberth and Noordung had great influence. The German V-2 rocket, a missile with a range of about 300 miles, became a prototype for both U.S. and Russian rockets after the war.

In 1945, renowned German rocket engineer Wernher von Braun came to the U.S. to build rockets for the U.S. Army. In the 1950s, he worked with *Collier’s* magazine and Walt Disney Studios to produce articles and documentaries on spaceflight. In them, he described a wheel-shaped space station reached by reusable winged spacecraft. Von Braun saw the station as an Earth-observation post, a laboratory, an observatory, and a springboard for Moon and Mars flights.

On October 4, 1957, the Soviets launched Sputnik 1. This triggered the Cold War competition between the U.S. and Soviet Union in space which characterized the early years of the Space Age—competition replaced today by cooperation in assembly of the International Space Station. In response to Sputnik, the U.S. established the National Aeronautics and Space Administration in 1958 and started its first man-in-space program, Project Mercury, in 1959.

Apollo and Space Stations (1958-1973)

Project Mercury had hardly begun when NASA and the Congress looked beyond it, to space stations and a permanent human presence in space. Space stations were seen as the next step after humans reached orbit. In 1959, A NASA committee recommended that a space station be established before a trip to the moon, and the U.S. House of Representatives Space Committee declared a space station a logical follow-on to Project Mercury.

In April 1961, the Soviet Union launched the first human, Yuri Gagarin, into space in the Vostok 1 spacecraft. President John F. Kennedy reviewed many options for a response to prove that the U.S. would not yield space to the Soviet Union, including a space station, but a man on the moon won out. Getting to the moon required so much work that the U.S. and Soviet Union were starting the race about even. In addition, the moon landing was an unequivocal achievement, while a space station could take many different forms. Kennedy’s choice proved wise–in January 1969, *Soyuz 4* and *Soyuz 5* docked in Earth orbit, the first time two piloted spacecraft came together in space, and the Soviet Union declared that they constituted the first space station. Few accept the claim today, but the *Soyuz 4*/*Soyuz 5* docking might have been a blow to U.S. prestige had Kennedy picked the wrong goal.

Space station studies continued within NASA and the aerospace industry, aided by the heightened interest in spaceflight attending Apollo. In 1964, seeds were planted for *Skylab*, a post-Apollo first-generation space station. Wernher von Braun, who became director of NASA's Marshall Space Flight Center, was instrumental in *Skylab's* development.

By 1968, a space station was NASA's leading candidate for a post-Apollo goal. In 1969, the year *Apollo 11* landed on the moon, the agency proposed a 100-person permanent space station, with assembly completion scheduled for 1975. The station, called Space Base, was to be a laboratory for scientific and industrial experiments. Space Base was envisioned as home port for nuclear-powered tugs designed to carry people and supplies to an outpost on the moon.

NASA realized that the cost of resupplying a space station using expendable rockets would quickly exceed the station's construction cost. The agency also foresaw the need to be able to return things from a space station. A reusable spacecraft was the obvious solution. In 1968, NASA first called such a spacecraft a space shuttle.

Skylab (1973-1974)

In May 1973, the U.S. launched the *Skylab* space station, our only experience with long-duration microgravity research to date. *Skylab* was launched atop a Saturn V rocket similar to those that took astronauts to the Moon. The rocket's third stage was modified to become an orbital workshop and living quarters for three-person crews. Non-reusable Apollo spacecraft originally designed for Moon missions ferried astronauts to and from the station. *Skylab* hosted three different crews for stays of 28, 56, and 84 days. *Skylab* astronauts conducted medical tests and studied microgravity's influence on fluid and material properties. The crews also made astronomical, solar, and Earth observations. Long-duration microgravity research begun on *Skylab* will continue and be refined on the International Space Station.

Skylab proved that humans could live and work in space for extended periods. The station also demonstrated the importance of human involvement in construction and upkeep of orbital assets–the first *Skylab* crew performed an emergency spacewalk to free a solar array jammed during the station's launch.

Skylab was not designed for resupply, refueling, or independent reboost. When the last *Skylab* crew headed home in February 1974, NASA proposed sending a space shuttle to boost *Skylab* to a higher orbit or even to refurbish and reuse the station. But greater than expected solar activity expanded Earth's atmosphere, hastening *Skylab*'s fall from orbit, and shuttle development fell behind schedule. *Skylab* reentered Earth's atmosphere in 1979.

NASA Responds to Changing Priorities (1974-1979)

Shuttle was originally conceived as a vehicle for hauling people and things back and forth between Earth and a space station. People and the supplies they needed for a long stay in space would go up, and people and the industrial products and experiment samples they made on the station would come down. But economic, political, social, and cultural priorities in the U.S. shifted during the Apollo era. Despite Apollo's success, NASA's annual budgets suffered dramatic cuts beginning in the mid-1960s. Because of this, NASA deferred plans for a permanent space station until after the space shuttle was flying, and explored international cooperative space projects as a means of filling in for a permanent station.

The U.S. invited Europe to participate in its post-Apollo programs in 1969. In August 1973, Europe formally agreed to supply NASA with Spacelab modules, mini-laboratories that ride in the space shuttle's payload bay. Spacelab provides experiment facilities to researchers from many countries for up to two weeks–an interim space station capability. Spacelab 1 reached orbit in 1983, on the ninth space shuttle flight (STS-9). European contributions to International Space Station, a laboratory module and a supply module, are based on Spacelab experience and technology.

U.S. and Soviet negotiators discussed the possibility of a U.S. shuttle docking with a Soviet *Salyut* space station. This was an outgrowth of the last major U.S.-Russian joint space project, *Apollo-Soyuz*, the first international spacecraft docking in 1975. The shuttle's ability to haul things down from space complimented *Salyut*'s ability to produce experiment samples and industrial products–things one would want to return to Earth. NASA offered the shuttle for carrying crews and cargo to and from *Salyut* stations and in return hoped to conduct long-term research on the *Salyut*s until it could build its own station, but these efforts ended with the collapse of U.S.-Soviet detente in 1979.

Defining the Goal and Building Support (1979-1984)

By 1979, space shuttle development was well advanced. NASA and contractor engineers began conceptual studies of a space station that could be carried into orbit in pieces by the space shuttle. The Space Operations Center was designed to serve as a laboratory, a satellite servicing center, and a construction site for large space structures. The Space Operations Center studies helped define NASA expectations for a space station.

The space shuttle flew for the first time in April 1981, and once again a space station was heralded as the next logical step for the U.S. in space. NASA founded the Space Station Task Force in May 1982, which proposed international participation in the station's development, construction, and operations. In 1983, NASA held the first workshop for potential space station users.

NASA Gets the Go-Ahead (1984-88)

These efforts culminated in January 1984, when President Ronald Reagan called for a space station in his State of the Union address. He said that the space station program was to include participation by U.S. allies.

With the presidential mandate in place, NASA set up the Space Station Program Office in April 1984, and issued a Request for Proposal to U.S. industry in September 1984. In April 1985, NASA let contracts on four work packages, each involving a different mix of contractors and managed by a separate NASA field center. (This was consolidated into three work packages in 1991.)

This marked the start of Space Station Phase B development, which aimed at defining the station's shape. By March 1986, the baseline design was the dual keel, a rectangular framework with a truss across the middle for holding the station's living and working modules and solar arrays.

By the spring of 1985, Japan, Canada, and the European Space Agency each signed a bilateral memorandum of understanding with the U.S. for participation in the space station project. In May 1985, NASA held the first space station international user workshop in Copenhagen, Denmark. By mid-1986, the partners reached agreement on their respective hardware contributions. Canada would build a remote manipulator system similar to the one it had built for the space shuttle, while Japan and Europe would each contribute laboratory modules. Formal agreements were signed in September 1988. These partners' contributions remain generally unchanged for International Space Station.

In 1987, the dual keel configuration was revised to take into account a reduced space shuttle flight rate in the wake of the Challenger accident. The revised baseline had a single truss with the built-in option to upgrade to the dual keel design. The need for a space station lifeboat–called the assured crew return vehicle–was also identified.

In 1988, Reagan gave Space Station a name–*Freedom*. Space Station *Freedom*'s design underwent modifications with each annual budget cycle as Congress called for its cost to be reduced. The truss was shortened and the U.S. Habitation and Laboratory modules reduced in size. The truss was to be launched in sections with subsystems already in place. Despite the redesigns, NASA and contractors produced a substantial amount of hardware. In 1992, in moves presaging the current increased cooperation between the U.S. and Russia, the U.S. agreed to buy Russian *Soyuz* vehicles to serve as *Freedom*'s lifeboats (these are now known as *Soyuz* crew transfer vehicles) and the shuttle-Mir program (now International Space Station Phase I) got its start.

International Space Station (1993-2012)

In 1993, President William Clinton called for the station to be redesigned once again to reduce costs and include more international involvement. To stimulate innovation, teams from different NASA centers competed to develop three distinct station redesign options. The White House selected the option dubbed Alpha.

In its new form, the station uses 75% of the hardware designs originally intended for the *Freedom* program. After the Russians agreed to supply major hardware elements, many originally intended for their *Mir 2* space station program, the station became known as International Space Station. Station assembly will begin with the launch of the Russian-made FGB, a propulsion module which will provide guidance, control, and orbit maintenance for the station as it grows, permitting expansion to basic operational capability much earlier than *Freedom*. This offers new opportunities to all the station partners by permitting early scientific research.

Program management also underwent redesign. The three-work-package system was scrapped in favor of a simpler, more straightforward host center/prime contractor arrangement. This streamlined management and reduced program costs and red tape. Johnson Space Center became host center for the space station program, and Boeing became prime contractor. NASA and Boeing teams were housed together at JSC to increase efficiency through improved communications.

JSC's strong experience in both engineering and spaceflight operations means efficient evolution from station development to station operations—important in part because operations will begin early in the International Space Station assembly sequence. Boeing was selected for its experience in integrating and outfitting *Freedom* modules, and for its successful application of the concept of integrated product teams (IPTs) to its federal government contracts—for example, in the development and manufacture of the 767 AWACS airplane and the Comanche helicopter for the Department of Defense.

Individual IPTs are charged with overseeing various aspects of the complex station program. They contain representatives from all the major groups involved in station development and operations, such as engineering, the flight crew, and mission operations personnel. If a problem arises during development, all the major groups have inputs to its solution. This prevents any one group from solving a problem on its own in a manner that creates new problems for other groups, streamlining the development process. The effective team relationships resulting from these practices are producing space station operations plans and designs faster and cheaper than ever before.

The International Space Station program is divided into three phases. Phase I, an expansion of the shuttle-Mir program begun in 1992, is giving Russian and U.S. engineers, flight controllers, and astronauts experience in working together and U.S. astronauts long-duration space experience aboard the *Mir* space station. Hardware is being tested and validated. This experience and hardware will be applied in Phases II and III, when the International Space Station is assembled in Earth orbit. Phase II begins in late 1997, with a core station assembled in Earth orbit by mid-1999. During Phase III, assembly flights will be interspersed with flights dedicated to research on the station. International Space Station operations are planned to continue for 10 years after assembly is completed in mid-2002.

Phase I of the International Space Station program kicked off in February 1994 with STS-60, the first Phase I flight, when cosmonaut Sergei Krikalev worked beside American astronauts in Space Shuttle *Discovery*, and continued in February 1995, when *Discovery* rendezvoused with *Mir* during the STS-63 mission with cosmonaut Vladimir Titov aboard. In March 1995, U.S. astronaut Dr. Norman Thagard lifted off in the Russian *Soyuz-TM 21* spacecraft with two Russian cosmonauts for a three-month stay on Mir. In June 1995, on the STS-71 mission, Space Shuttle *Atlantis* will dock with the *Mir* station for the first time and pick up Thagard and his colleagues, plus experiment samples and other items from the station, for return to Earth. Six more shuttle-*Mir* dockings and four more long-duration stays by U.S. astronauts aboard *Mir* are planned in Phase I.